# ELECTRICAL PROTECTION OF BURIED PLANT

**Purpose:** The purpose of this addendum is to clarify references to gas tube arresters to bring these references into alignment with TE & CM Section 823, as well as to discuss protection practices for "crosstalk screened cable facilities."

**Deletions:**

1. Delete paragraph 2.23. Make a notation stating: "See Addendum No. 2."

2. Delete paragraph 3.12. Make a notation stating: "See Addendum No. 2."

**Additions:**

1. Add new paragraph 2.23 to read as follows:

2.23 Loading coils meeting REA specifications are designed to withstand substantial lightning surges without damage. Present designs will withstand current surges which approach the fusing current of 28-gauge wire. While this fusing current is less than that of 24-gauge cable, it is large enough that only a small percentage of surges reaching cables will cause loading coil damage. Therefore, gap protection of loading coils in buried plant is not normally required. In very severe lightning damage areas, protection for loading coils can be added at a later date if experience indicates the need. Where loading coil protection is necessary, standard or heavy duty gas tubes with a slowly rising dc breakdown voltage of approximately 350V should be used. It is recommended that these tubes be connected in a longitudinal nongrounded bypass configuration, as discussed in TE & CM 822.

2. Add new paragraph 3.12 to read as follows:

3.12 Gas Tube or Equivalent Arresters at Junctions with Facilities Serving Severely Exposed Stations - Terminal blocks equipped with standard or heavy duty gas tube arresters having dc breakdown voltages of 800 volts or greater and installed in suitable mountings and enclosures are recommended at junctions between buried wire or cable and facilities

serving stations that are severely exposed to lightning (such as fire towers and radio towers) regardless of the length or type of connecting facilities. Yellow coded (10 mil) carbon blocks may be used as an alternative to gas tubes. The wide gap spacing of the carbon blocks should reduce maintenance of these units to such an extent that they should be a very acceptable low cost substitute for the gas tubes.

3. Add new paragraph 3.136 to read as follows:

3.136 The recent increased use of pulse code modulation (PCM) carrier systems, with the resultant increased concern for near end cross talk (NEXT) has led to the development of a cable in which the pairs are divided into two bundles which are isolated from each other by a "screen" designed to reduce the crosstalk from one bundle to the other primarily by reducing the capacitance unbalance between pairs. Because this screen is within the core of the cable and adequate dielectric is not provided between the pairs and screen, the screen should not be treated as a shield where electrical protection is concerned. It is recommended that the screen not be connected to ground at any point and that it be made electrically discontinuous at pedestals.

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**Purpose:** The purpose of this addendum is to add the requirement to bond metallic buried plant housings to vertical pole ground wires on power poles if the buried plant housing is mounted on the power pole or within a man's reach of the power pole. If they are not bonded together the vertical pole ground wires that are connected to multigrounded neutral conductors may become energized during power fault conditions and thereby create a shock hazard to anyone simultaneously contacting the vertical pole ground wire and the buried plant housing.

**Additions:** After Section 5, Page 7, add:

6. Bonding of metallic buried plant housings to vertical pole ground wires.

6.1 When a metallic buried plant housing is mounted on a power pole, the grounding connector of the housing shall be bonded with a #10 AWG bare copper wire to the vertical pole ground wire, if present, on the pole. The purpose of this bond is to maintain the ground wire and the buried plant housing at the same potential, thereby preventing a shock hazard that otherwise might exist during a fault condition on the power line.

6.2 With certain types of cable carriers, the carrier equipment manufacturers have recommended that the carrier equipment <u>not</u> be connected to an electric system ground. In such instances carrier equipment housings and/or metallic buried plant housings enclosing carrier equipment should be bonded to vertical pole ground wires as required herein in paragraph 6.1, but the carrier circuitry and chassis should be isolated from the metallic housing by insulation having at least 20 kV dc dielectric strength. The provision of this dielectric between the carrier circuitry and the housing makes it possible to use floating by-pass protection or protection grounded to a remote separate ground, and still maintain the buried housing at the same potential as the vertical pole ground wire. It is the responsibility of the carrier equipment suppliers to provide the 20 kV dielectric strength between the carrier circuitry and chassis, and the metallic housing. See TE & CM-822 for additional details on carrier protection.

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## 1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, and other interested parties with information for use in the design, construction, and operation of REA borrowers' telephone systems. More specifically this section includes the electrical protection practices for buried cables and wires having plastic-insulated conductors and jackets.

1.2 This section replaces Section 816, Issue No. 2, dated June 1965, and Addendum No. 1, dated November 1966. The principal changes included in this revision are the elimination of washer gaps, and the addition of gas tube protection for severe exposures. A general review and updating of the previous information is also included. Data previously included in the addendum has been updated and incorporated as an integral part of the section.

## 2. ELECTRICAL PROTECTION CONSIDERATIONS

2.1 Dielectric Qualities of Plastic-Insulated (PIC) Cable and Wire - Polyethylene insulated conductor and jacketed cable and wire have long been recognized as requiring a minimum of electrical protection due to their inherent high dielectric strength and quality. With difficulties due to dielectric failure having been reduced to a very minimal amount through the extensive application of PIC cable and wire, the remaining possible effect derived from foreign potentials on the telephone plant is the fusing of the cable or wire conductors. While finer gauge conductors are more susceptible to this type of damage, the economic advantage in their utilization will usually outweigh the higher rate of fusing incidence as compared with coarser gauge facilities.

2.2 Lightning Protection - Buried cable and wire are not normally as susceptible to damage from lightning surges as other categories of outside plant. However, buried plant may be subjected to lightning damage in one of the following ways: (1) By direct strokes to the shield or strokes to ground, which are to the shield; (2) by surges conducted to the buried plant from connecting facilities which are struck; (3) by induction from nearby strokes to ground; and (4) by currents developed due to a rise in ground potential at stroke points near grounded station protectors or other grounded facilities. While the dielectric of PIC cable will withstand most of the surges that occur from items 2, 3, and 4 above, direct lightning strokes will normally cause damage to the cable, due to the magnitude of currents involved. However, direct strokes to buried cable occur very infrequently and are not a major source of trouble. There is no feasible method within reasonable economic bounds of protecting against direct lightning strokes.

2.21 Current surges which reach buried cable from conductors of connecting plant such as buried line wire, buried services, or aerial noncable type plant, are usually confined to the conductors by the high dielectric strength of the plastic insulation on the conductors and the inner jacket. Frequently the exposed connecting conductors are of coarser gauge than the buried cable conductors to which they connect. Both of these factors tend to increase the probability of fusing the cable conductors.

2.22 The much greater use of buried fine gauge cable conductors in modern telephone systems has resulted in conductor fusing becoming more prevalent than dielectric failure.

2.23 Loading coils meeting REA specifications are designed to withstand substantial lightning surges without damage. Present designs will withstand current surges which approach the fusing current of 28-gauge wire. While this is less than the fusing current for #24-gauge cable, it is large enough so that only a small percentage of surges reaching cables will cause loading coil damage. Because of this, gap protection of loading coils in buried plant is not normally required. In unusually severe lightning damage areas, protection for loading coils can be added at a later date if experience indicates the need. Where loading coil protection is necessary two 2-electrode gas tubes in a longitudinal ungrounded by-pass configuration are recommended.

2.3 Power Contact Protection - For the purposes of this section, cable and wire facilities which are actually buried in the earth are not considered as being exposed to power line contacts except those buried in the same trench with power distribution cables. Protective measures are, therefore, not required for buried plant except for those which may be required for the protection of connecting facilities, subscriber stations, and exposed aerial inserts as prescribed in practices covering such plant and as supplemented herein. Aerial inserts in buried [illegible] considered as being exposed when the [illegible] contacted by power line conductors

operating in excess of 300 volts to ground. Where joint buried construction is involved, protection measures should be applied as described in REA publication "Design and Construction of Joint Buried Plant - Electric and Telephone" dated June 1967 and marked "File with TE & CM-640."

3. APPLICATION OF LIGHTNING PROTECTION MEASURES

3.1 Dielectric protection of buried plant is limited to the following measures:

(a) Termination of cable pairs at junctions with open wire.

(b) Gas tube or equivalent arresters at junctions with facilities serving severely exposed stations.

(c) Bonding and grounding of buried wire and cable shields.

3.11 Termination of Cable Pairs at Junctions with Open Wire - Where one or more pairs are extended by open wire at the end of a main cable lead, all pairs should be terminated on unprotected terminal blocks. Where one or more pairs are extended by open wire at a tap point along the cable, enough unprotected terminal blocks should be provided to terminate the pairs that are to be extended by open wire. The number of cable pairs terminated should equal the number of pairs of terminal studs installed.

3.111 It has been determined by tests that unprotected terminal blocks, with normally spaced terminal studs equipped with nuts, will break down under typical lightning surges at values below the surge dielectric strength of buried cable and wire conductors. Effective protection against dielectric failure of PIC cable pairs will be provided if all pairs in the cable at or within 1/2 mile of an open wire junction are terminated on terminal blocks.

3.112 For example, at the deadend of an 18-pair cable which is extended by 4 pairs of open wires, three 6-pair terminal blocks should be installed and all 18 pairs should be terminated on the terminal studs of the terminal blocks. This limits the difference in potential between any cable conductor and every other cable conductor to the voltage breakdown between terminal studs. At a two-pair open wire branch tap point along the cable, a 6-pair terminal block should be installed and four pairs in addition to the two open wire pairs should be terminated on the terminal studs.

3.113 Greater protection would be provided if branch tap points along the cable were protected the same as at deadends; i.e., all pairs terminated. However, branch taps along the cable are likely to be shorter and, therefore, not as good lightning receiving antennas, as longer open wire extensions from deadends. Also, a much greater number of cable pairs may appear at a branch tap point than at a deadend so the cost of applying terminal

blocks for protection would be greater. The greater number of terminal blocks required to terminate all pairs of the cable at branch tap points along the route in most instances would produce only marginal improvement in overall lightning protection. Additional terminal blocks would also be objectionable because of the increased number of leakage paths they would produce.

3.12 Gas Tube or Equivalent Arresters at Junctions with Facilities Serving Severely Exposed Stations - Terminal blocks equipped with gas tube arresters having 800 volts or greater breakdown and installed in a suitable mounting and enclosure are recommended at junctions between buried wire or cable and facilities serving stations that are severely exposed to lightning (such as fire towers and radio towers) regardless of the length or type of connecting facilities. Yellow coded (10 mil) carbon blocks may be used as an alternative to gas tubes.

3.13 Bonding and Grounding of Buried Wire and Cable Shields.

3.131 Complete bonding of shields of buried cable and wire to maintain electrical continuity of shields throughout the buried plant and its connections to aerial plant, central offices, and subscriber station protectors is required. Grounding of buried cable and wire shields is advantageous from lightning protection considerations under some circumstances and is disadvantageous under others. Grounding of buried cable and wire shields is required under some circumstances from power contact considerations as discussed herein, and is normally required at each end of a cable in order to make the shield function as a noise shield.

3.132 With buried plant, to a considerably greater extent than in aerial plant, grounds on shields may conduct stroke currents to the cable rather than away from the cable. Similarly, the connection of buried shields to MGN grounds may be disadvantageous from lightning protection considerations because a relatively large number of surges may be fed into the buried telephone plant from strokes to the aerial power system.

3.133 Because of the probability that any ground connection may act as a path by which lightning surge currents are conducted to buried plant, no grounds should be placed on buried plant except as required in paragraphs 3.134 and 5, herein, or for noise mitigation. The metal stake of a buried terminal housing is not considered to be a "ground."

3.134 The shields of all buried wires and cables entering a central office should be bonded to each other and interconnected with the central ground bus or grounding conductor. This measure eliminates harmful ences of potential between the various cables entering the central and provides one of the two grounds necessary for a noise shield.

At junction points the shields and support wires of interconnecting facilities should be bonded to the metallic shield of the main buried

cable or wire. The grounding connector provided in terminal housings should be used to facilitate making these connections. The shield of buried service wires should likewise be bonded to the metallic shield of the main cable and connected at the subscriber end to the station protector ground terminal.

3.2 Protection of connecting facilities having appreciably lower dielectric strength than plastic-insulated conductor (PIC) cable and wire is required as follows:

(a) Arresters at the central office.

(b) Arresters at junctions with paper-insulated cable.

(c) Arresters at carrier repeaters and terminals.

3.21 Arresters at the Central Office - Provide main frame arrester protection on all cable pairs entering the central office.

3.22 Arresters at Junctions with Paper-Insulated Cable - Where aerial type station drop wires or aerial wire facilities (all types) are connected to buried plant within 1 mile of a junction of plastic-to-paper cable, the buried wire or cable pairs serving the station drop wires or other aerial wire facilities should be connected to the paper-insulated cable through protected cable terminals installed on the aerial cable. The cable terminals should be equipped with blue coded arrester gaps (700 volts rms breakdown value) for protection of the paper- or pulp-insulated cable.

3.23 Carrier repeaters and terminals and most other electronic equipment used on cable pairs have low dielectric strength compared with the dielectric strength of cable pairs. Such equipment must, therefore, be protected in accordance with REA TE & CM-822, "Electrical Protection of Carrier Equipment."

## 4. APPLICATION OF POWER CONTACT PROTECTION MEASURES

4.1 Aerial Inserts - Aerial inserts
type cable, aerial type cable,
When an aerial insert of any type is
with, crossing under, or otherwise su
ductors operating at voltages in exce
considered as exposed. Support strar
should be effectively grounded by cor
available, effective grounding by dri
The support strand of aerial inserts
grounded at only one point if the grc
For aerial inserts exceeding 1000 fee
effectively grounded at each end and

4.12 The conductors of exposed aerial inserts in buried wire or cable must be isolated from the buried portions on both sides of the insert in order to maintain the unexposed status of the buried plant. This is necessary in order that fuseless-type station protectors may be used and it may be accomplished by any of the following procedures.

4.121 If the conductors of the buried plant on both sides of the aerial insert are 24-gauge copper or smaller, no fuse links are required. Buried type wire or cable may be used for the aerial insert following construction practices for aerial cable.

4.122 If the conductors of the buried plant are larger than 24-gauge copper, the preferred construction is to install 24-gauge cable as the aerial insert. The 24-gauge insert then provides the necessary fusing coordination with the connected stations on both sides of this insert. Where the aerial insert extends for more than a few spans, the effect of the use of 24-gauge on transmission should be checked.

4.123 If the conductors of both the buried plant and the aerial insert are larger than 24-gauge, isolation of the exposed aerial insert should be accomplished by providing 24-gauge copper fuse links between the aerial insert and the buried portions of the cable. These fuse links should be applied at both ends of the exposed insert, as shown in Figure 1. In order to minimize the cost of isolating aerial inserts, the 24-gauge links should usually be installed in terminal housings that are required for other purposes at points nearest to each end of the aerial insert. Color-coded 24-gauge leads at least 8 inches long should be spliced in series with each conductor of the cable between the end of the buried portion of the cable and the adjoining end of the aerial insert. The color code must be preserved. If subscribers' services or buried wire branch tap leads are distributed from the buried plant terminal housings involved, they should be connected to the unexposed side of the fuse link. Exposed aerial taps should be connected to the exposed side of the fuse links. The shields of all cables or wires appearing in the buried plant terminal housings should be bonded together and grounded to the same ground electrode to which the support strand is grounded. A typical exposed aerial insert is shown in Figure 1.

4.2 Aerial Line Extensions - All aerial noncable-type line extensions from buried plant should be connected to the buried wire or cable through a wire link capable of safely fusing at currents less than the ampacity (current carrying capacity in amperes) of the subscriber's service. The 24-gauge copper leads connected to terminal blocks or 20-gauge bridle wires are adequate for this purpose. The term "noncable-type circuits" as used here refers to wire circuit facilities not enclosed in a metallic shield. Buried wire is classified, for protection purposes, as a "cable type" facility.

4.21 Where buried plant facilities are extended by exposed aerial wire facilities, power contact protection should be applied to the aerial facilities in accordance with applicable REA practices. Where the applicable

practices require protection devices at the junction with buried plant, the low impedance ground required for the power protection device should be utilized to provide additional lightning protection to the buried plant. This can be accomplished by bonding the buried cable or wire shield to the grounding conductor or ground electrode of the power contact protector.

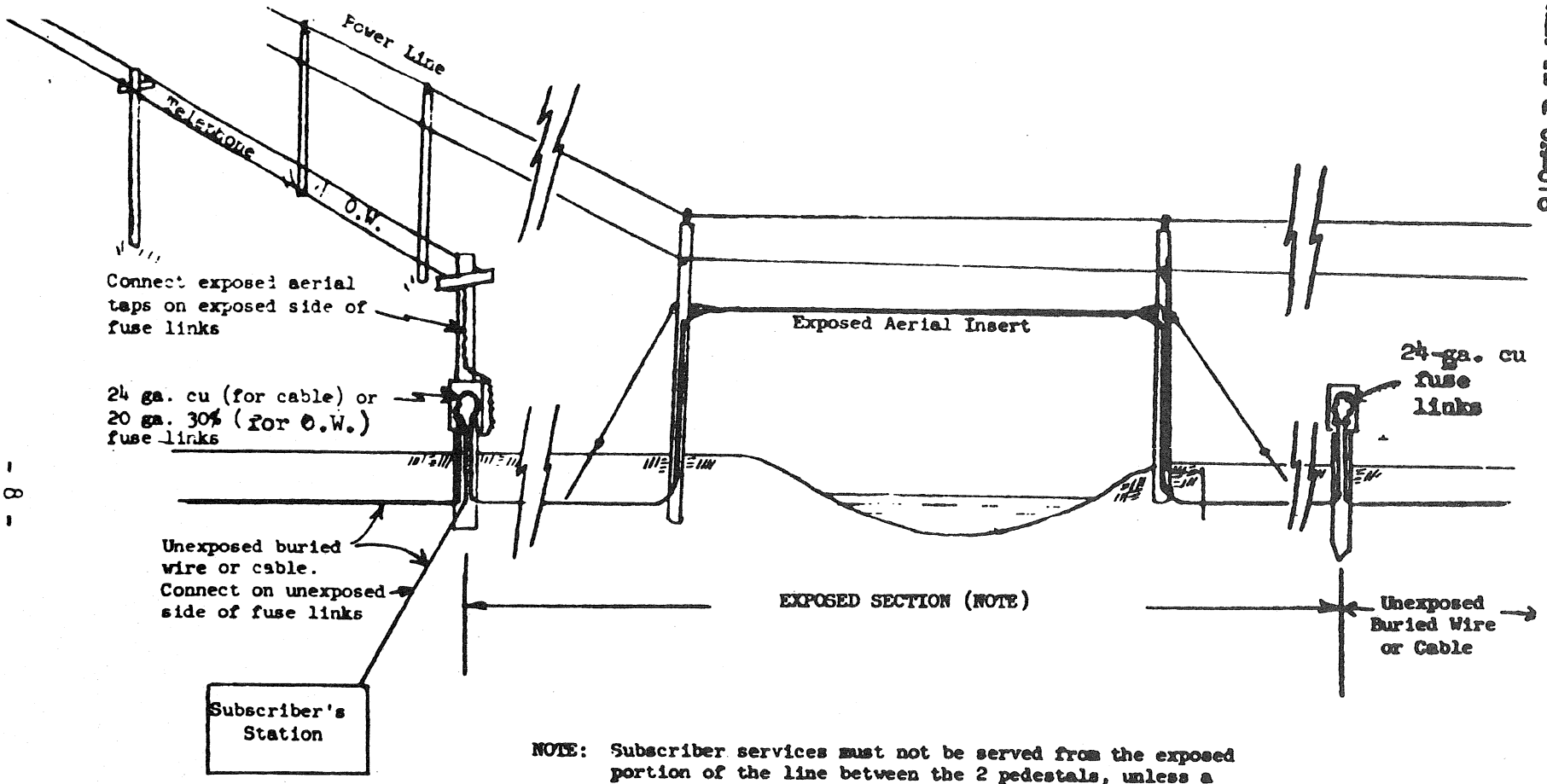
4.3 Aerial Drop Wires Connected to Buried Plant - Where economically feasible, the connection of aerial drop wires to buried wire or cable should be avoided in favor of buried services.

4.31 Aerial drop wires exposed to the possibility of contact with electric distribution facilities operating in excess of 300 volts to ground should be connected to the buried facilities through a 24 AWG copper fuse link or a 20 AWG 30 percent conductivity copper-steel bridle wire. This fuse link is required as a protective measure to prevent large fault currents from reaching other stations served by the buried wire or cable. It will also prevent damage to larger gauge buried facilities. The station being served should be protected in accordance with applicable station protection practices.

## 5. GROUNDING OF BURIED WIRE AND CABLE SHIELDS

5.1 As previously indicated, grounding of buried wire or cable shields at junctions with other types of facilities cannot usually be justified solely for lightning protection purposes. However, because shield grounds may be needed to mitigate noise and also because shield grounds at junctions with aerial wire facilities may be helpful in deenergizing power contacts, buried wire and cable shields should be grounded by connection to a power MGN or to a low resistance driven rod at junctions with all aerial open wire and distribution wire facilities.

5.12 Except as specified in paragraph 5.1, no grounding of cable shields is required at junctions with other buried plant, aerial drop wires, aerial cable, or at other points along the buried cable.




NOTE: Subscriber services must not be served from the exposed portion of the line between the 2 pedestals, unless a fuse link is inserted in series with the service.

FIGURE 1
Protection at Exposed Aerial Insert in Buried Plant Using Fuse Links